

The Cleveland Museum of Art Distance Learning Program

Arms, Armor and Simple Machines

Grades 4-6

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Teacher Note: Please make copies of the Cranach image and the Viewing Guides for students to use during the lesson.

Teacher Information Guide

Distance Learning at The Cleveland Museum of Art

Arms, Armor and Simple Machines

Grades 4-6

Program Objectives:

Students will learn and understand...

1. Students will learn to recognize the **six simple machines**: lever, screw, wedge, pulley, inclined plane, and wheel and axle.
2. Encourage students to appreciate the artistic design of objects as well as observe their functions.

National Education Standards:

For Fine Arts - Visual Arts (grades 5-8):

- Using knowledge of structures and functions.
- Understanding the visual arts in relation to history and cultures.
- Making connections between visual arts and other disciplines.

For Science (grades 5-8):

- Physical science
- Science and technology
- Personal and social perspectives
- History and nature of science

In this program, students will learn how the five simple machines (lever, pulley, inclined plane, wheel and axel and screw) have played a part in the development of arms and armor. Using examples from the Cleveland Museum of Art's famed Armor Court, students will compare different types of armor and discover how they have been used in battle, sport and for ornamentation. Students will also be able to identify and apply the five simple machines in everyday objects.

Pre-Requisite Activities:

During the Lesson there will be a building activity. Please pay particular attention to item 2 on this list.

1. Students should have a basic understanding of simple machines: **Lever, Wedge, Screw, Inclined Plane, Pulley, and Wheel and Axle.** We will briefly discuss the controversy surrounding the number and classification of the simple machines (See “Teacher Resources” for more information.)

2. CATAPULT BUILDING – If your class would like to build simple catapults during the videoconference, please bring the following instructions and materials:

Simple Tension Catapult Materials & Instructions

For 30 students working in pairs

30 Popsicle Sticks

15 pens, pencils or markers of various size

15 plastic spoons

1 bag of assorted rubber bands

1 bag of mini-marshmallows

1. Take one of your popsicle sticks and place the plastic spoon on top of it, so the end of the handle is even with the end of the popsicle stick (the back of the spoon's bowl should just rest on the other end)
2. Using a smaller rubber band, attach the spoon to the Popsicle stick to the neck of the spoon. This is now the “throwing arm.”
3. Place the other Popsicle stick underneath the paired spoon and Popsicle stick.
4. Fold one regular sized (3-4” long) rubber band by twisting it into an “8” shape, then folding the two sides over onto each other.
5. Wrap this ‘doubled’ rubber band a few times over end of the sticks and spoon away from the spoons bowl.
6. Slip a pen, pencil or marker between the two Popsicle sticks, which should be bound together only at the non-cup end. Get it within a few millimeters of the rubber band.
7. The catapult is complete. To fire it, place the fingers of your hands onto the pen or marker, and with one of your thumbs, pull back the spoon. Have your buddy load the marshmallow (please don't light it on fire), and when nobody is in the way, fire.
8. Have the students figure out how you can make the marshmallow go farther. They should feel free to move the catapult around (ideally, by adjusting the angle), or to change the fulcrum under the throwing arm.

3. To introduce students to the topic of Arms and Armor, read *The Making of a Knight* by Patrick O'Brien (Watertown, MA: Charlesbridge Publishing, 1998). Set in the Middle Ages in England, this story traces the main character's journey from an inexperienced seven-year-old page to his knighthood at the age of twenty-one.

Selected Vocabulary:

Machine – a simple device that affects the force, or effort, needed to do a certain amount of work.

Simple machines – the lever, the pulley, the inclined plane, and the wheel and axle; each machine affects the direction or the amount of effort needed to do work.

Work – work, in physics, is the amount of force used to move another object multiplied by the distance over which the force is applied; this can be written in mathematical terms: $\text{Work} = \text{Force} \times \text{Distance}$

Inclined plane – an object that decreases the effort to lift an object by increasing the distance over which the effort is applied; this increase in distance allows a person to move a large object to a certain height while applying less force than would otherwise be needed; the tradeoff is that with the inclined plane, the person must move the object a farther distance. Ramps and staircases are simple examples of inclined planes.

Screw – a helical (a three-dimensional spiral) inclined plane wrapped around a cylinder or cone.

Wedge – A moveable inclined plane.

Pulley – the pulley is a special type of wheel, called a sheave, which has a groove cut into the edge to guide a rope, cable, or chain. If a single pulley is used, the mechanical advantage is 1, and the only advantage of using the pulley is that the direction of the force is changed. (example: window blind, pulley at the top of a flagpole) When multiple pulleys are combined (called a block and tackle), they can have mechanical advantages greater than 1, because they increase the distance the rope travels, thereby increasing the distance over which the effort is applied.

Wheel and axle – similar in appearance to a pulley, with one major difference: the wheel is fixed to the axle, as is the steering wheel of a car. A user applies effort to the large outer wheel of the steering wheel to move the load at the axle.

Lever – consists of a bar that rotates around a pivot point, which is called the fulcrum; the force applied by the user is the effort; the object being lifted is called the load.

- **Class 1 lever:** the fulcrum lies between the effort and the load, as in a seesaw.
- **Class 2 lever:** the fulcrum lies at one end, the effort is applied at the other end, and the load is in the middle, as in a wheelbarrow.
- **Class 3 lever:** the fulcrum is again at one end, but the load is at the other end, and the effort is applied in the middle. The human forearm is a Class 3 lever. The

elbow is the fulcrum, and the forearm muscles apply the effort between the elbow and hand. Tweezers are another example.

Chain maille – flexible armor made of thousands of hand-formed steel rings attached so as to create a mesh covering.

Crossbow – a medieval weapon consisting of a bow set across a wooden stock; the stock is grooved to direct an arrow and notched to hold the bowstring, which is drawn up by a cranequin and released by a trigger.

Cranequin – a crossbow winder consisting of a ratchet, a claw to grasp the cord, and a handle, used to wind the crossbow in order to fire its bolt.

Crossbow bolt – an arrow fired from a crossbow.

Petronel – a firearm of heavy caliber, used in the 15th to 17th centuries.

Wheel-lock hunting pistol – a firearm with a firing mechanism consisting of a rough wheel which spun on a flint when the trigger was pulled, throwing sparks into the pan and setting off the charge.

Complex machine – combinations of simple machines (doorknob: a wheel and axle system that transfers the force to a system of levers; automobile: the engine contains many levers, wheels and axles, and pulleys)

Renaissance – the transitional period of European history in which learning and the arts blossomed with a renewed interest in classical antiquity and medieval thought was gradually subjected to the beginnings of scientific scrutiny; though there are no fixed dates for the Renaissance, the years 1400-1600 roughly bracket the achievements of this era.

Teaching Extensions:

- 1) CMA provides one color copy of each of the four CMA artifacts to the class. Students are divided into groups of 3 or 4 and each group is provided a color copy. Each group is instructed to become “museum curators” and create an information card for the pictured artifact, describing the artifact, its function, and the simple or complex machines present in the artifact.

Images include: Half Armor for the Foot Tournament (1996.299); Two-handed Sword (1916.1508); Crossbow and Cranequin (1916.1725, 1916.2082) Lucas Cranach the Elder, Hunting Scene at Hartenfels Castle (1540, 1958.425)

- 2) Using the color copy of Field Armor for Man and Horse (1964.88), the class can closely examine the color picture, list and discuss simple and complex machines that are present, and explain their importance in accomplishing work and making work easier.

- 3) Pretend that you are living during the Renaissance period. Write a persuasive piece about why crossbows should be outlawed.
- 4) Look around the classroom or school environment and identify examples of simple and complex machines. List and discuss what work each object accomplishes and how each object makes work easier. Present your findings in a chart or graph form.

Teacher Resources:

Recommended Reading:

Bull, Stephen. *An Historical Guide to Arms and Armor*. New York: Facts on File, Inc., 1991.

Byam, Michele. *Arms and Armor* (Eyewitness Books). London: Dorling Kindersley Limited, 1988.

Fliegel, Stephen N. *Arms and Armor. The Cleveland Museum of Art*. Cleveland: The Cleveland Museum of Art, 1998.

Fowler, Allan. *Simple Machines*. New York: Children's Press, 2001.

Grafton, Carol Belanger. *Arms & Armor*. New York: Dover Publications, Inc., 1995.

Hodge, Deborah. *Simple Machines*. Toronto: Kids Can Press, 1995.

St. Andre, Ralph E. *Simple Machines Made Simple*. Englewood, Colorado: Teacher Ideas Press, 1993.

Websites:

Chivalry Kid zone – Cool Stuff for Children of all Ages.

<http://www.chronique.com/Kids/nobles.htm>

Both of these sites have links to several sites about Simple Machines.

<http://www.kidskonnnect.com/SimpleMachines/SimpleMachinesHome.html>

<http://surfaquarium.com/newsletter/machines.htm>

This site provides instructions on how to build another catapult. It's little more involved than the one we'll make during the conference.

<http://www.sci-experiments.com/catapult/catapult.html>

Arms, Armor & Simple Machines

Student Viewing Guide

Two-Handed Sword

Ways It Might Have Been Used:

- 1.
- 2.
- 3.

Crossbow and Cranequin

Designs that I see on these pieces:

- 1.
- 2.
- 3.
- 4.
- 5.

Parts of a Pistol That Are Simple Machines:

- 1.
- 2.
- 3.

Simple Machine Review:

Simple Machine:	Armor Court Example:	Work the object does:	Present Time Example:	Work the object does:

Simple/Complex Machines in School Environment:

- **Present your findings in a chart or graph**
- **Name the objects**
- **Identify whether they are simple machines or complex machines (S or C)**
- **Identify the specific simple machines found in the object**
- **Tell what work the object accomplishes**

Name of the object:	Simple or Complex Machine	Simple Machines found in the object	Work the object accomplishes

Arms, Armor and Simple Machines: Selected Images



Armor for Man and Horse with Völs-Colonna Arms
North Italy c. 1575
1964.88
The Cleveland Museum of Art©



Two-Handed Sword
Germany, Brunswick c.1574
1916.1508
The Cleveland Museum of Art©

**Arms, Armor and Simple Machines:
Selected Images**



Half Armor for the Foot Tournament
Pompeo della Cesa (Italian) c. 1590
1996.299
The Cleveland Museum of Art©



*Crossbow of Elector Augustus I of Saxony and Cranequin with
Arms of Elector Augustus I of Saxony*
Germany, Saxony c. 1553-1573
1916.1723
The Cleveland Museum of Art©

**Arms, Armor and Simple Machines:
Selected Images**



Hunting near Hartenfels Castle, Lucas Cranach (German, 1472 - 1553), c. 1540, 1958.425
The Cleveland Museum of Art©

What was a knight?

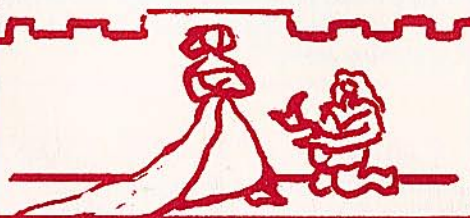
The term *knight* comes from the Old English *cniht*, or soldier. Above all the knight was a fighting man. But he also held a small estate, called a manor, from which he oversaw the life of a neighboring village or two. The manor was a gift from a more powerful lord, who, in turn, held his vast estates from the king. In this social system, called feudalism, all land was held in return for military service.

A knight was required to spend part of his manor's income on equipping himself for battle: a suit of armor, a sword, and a lance, and at least two well-trained war horses. In fact, so essential was a horse to knighthood, that both the French word for knight (*chevalier*) and the English term for the knight's honor code, the code of chivalry, come from the French word for horse—*cheval*.

How should a knight behave according to the rules of chivalry?

It wasn't an easy code to follow! On the battlefield he was supposed to be fierce, courageous, and victorious. Yet the Church told him to be merciful and to refrain from fighting other Christians. He was honor bound to be a loyal subject of his king, but at the same time, he had to obey the orders of the baron from whom he held his manor. Finally, at the end of a hard day's fighting, a knight was supposed to settle down and entertain the fancies of his ladylove. He therefore needed to know poetry, music, and tales of derring-do. Not least, he had to compete for his lady's honor and favor at the tournaments.

Knights, with the Church's blessing, were expected to fight for the defense of Christendom. The First and Second Crusades were thus perhaps the greatest acts of chivalry. Christian knights, promised entry to heaven, fought the Muslims for control of the cities of the Bible. Unfortunately, the other seven crusades were fought for less lofty ideals. In 1204 the Crusaders seized Constantinople, the gold-filled capital of the Byzantine Empire, their Christian ally!

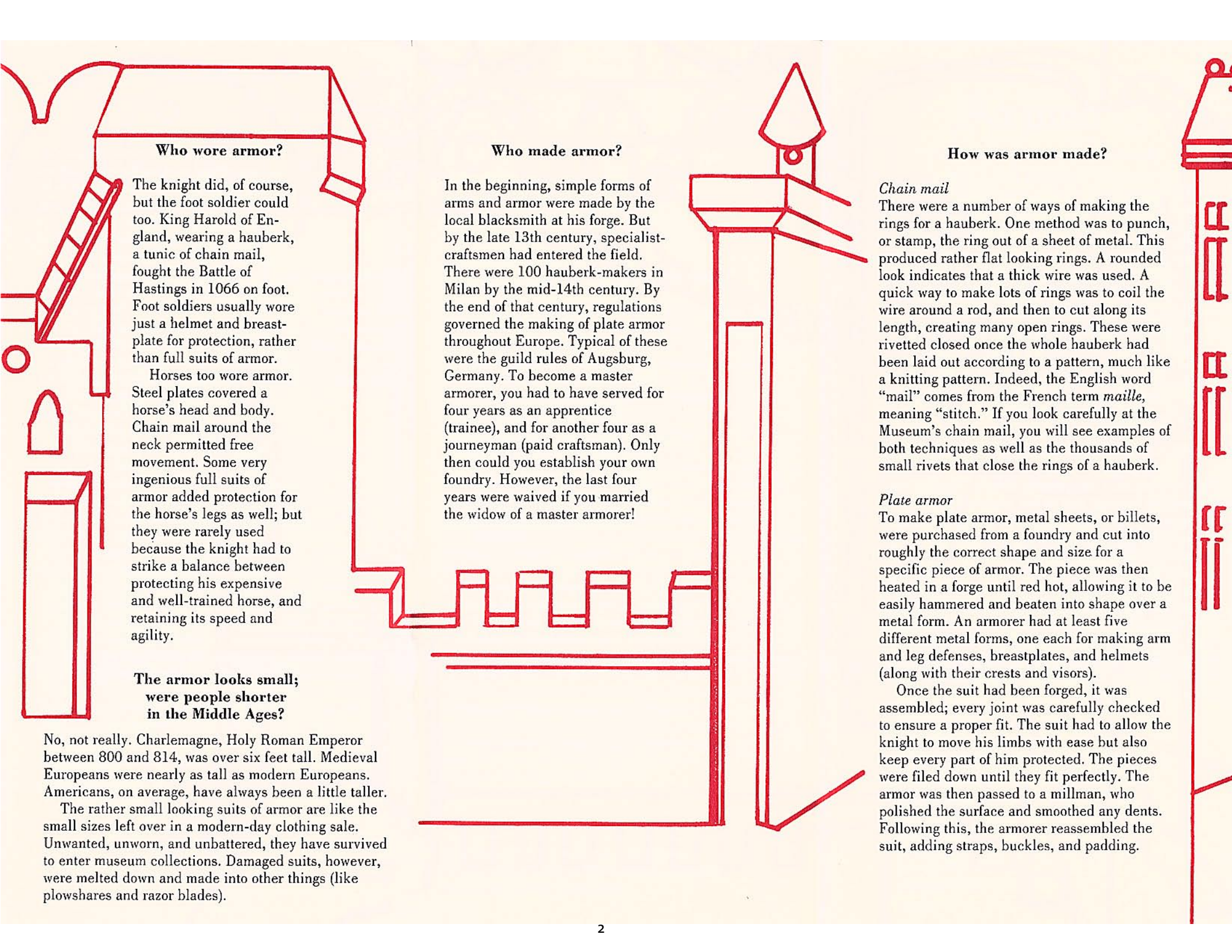


How did one become a knight?

The would-be knight, usually the son of a knight, had to undergo many years of training. Beginning at age six or seven, he was a page. For about seven years he served his lord and lady in their castle, receiving, in return, a smattering of learning and religion. When a teenager, the boy rose to the level of squire. In this position he learned how to dress his lord in armor,

wield a sword, and ride in tournaments. Her ladyship instructed the squire in the finer points of courtly love. Finally, when about 21, the squire could petition to be knighted by the king.

A quicker way to become a knight was to distinguish oneself on the battlefield and to be knighted on the spot by the king or one of his commanders. The simple ceremony of dubbing—tapping the knight on the shoulders with the point of a sword—is still used by the Queen of England in conferring knighthood, although today it is for distinguished persons in diverse fields.



Who wore armor?

The knight did, of course, but the foot soldier could too. King Harold of England, wearing a hauberk, a tunic of chain mail, fought the Battle of Hastings in 1066 on foot. Foot soldiers usually wore just a helmet and breastplate for protection, rather than full suits of armor.

Horses too wore armor. Steel plates covered a horse's head and body. Chain mail around the neck permitted free movement. Some very ingenious full suits of armor added protection for the horse's legs as well; but they were rarely used because the knight had to strike a balance between protecting his expensive and well-trained horse, and retaining its speed and agility.

The armor looks small; were people shorter in the Middle Ages?

No, not really. Charlemagne, Holy Roman Emperor between 800 and 814, was over six feet tall. Medieval Europeans were nearly as tall as modern Europeans. Americans, on average, have always been a little taller.

The rather small looking suits of armor are like the small sizes left over in a modern-day clothing sale. Unwanted, unworn, and unbattered, they have survived to enter museum collections. Damaged suits, however, were melted down and made into other things (like plowshares and razor blades).

Who made armor?

In the beginning, simple forms of arms and armor were made by the local blacksmith at his forge. But by the late 13th century, specialist-craftsmen had entered the field. There were 100 hauberk-makers in Milan by the mid-14th century. By the end of that century, regulations governed the making of plate armor throughout Europe. Typical of these were the guild rules of Augsburg, Germany. To become a master armorer, you had to have served for four years as an apprentice (trainee), and for another four as a journeyman (paid craftsman). Only then could you establish your own foundry. However, the last four years were waived if you married the widow of a master armorer!

How was armor made?

Chain mail

There were a number of ways of making the rings for a hauberk. One method was to punch, or stamp, the ring out of a sheet of metal. This produced rather flat looking rings. A rounded look indicates that a thick wire was used. A quick way to make lots of rings was to coil the wire around a rod, and then to cut along its length, creating many open rings. These were rivetted closed once the whole hauberk had been laid out according to a pattern, much like a knitting pattern. Indeed, the English word "mail" comes from the French term *maille*, meaning "stitch." If you look carefully at the Museum's chain mail, you will see examples of both techniques as well as the thousands of small rivets that close the rings of a hauberk.

Plate armor

To make plate armor, metal sheets, or billets, were purchased from a foundry and cut into roughly the correct shape and size for a specific piece of armor. The piece was then heated in a forge until red hot, allowing it to be easily hammered and beaten into shape over a metal form. An armorer had at least five different metal forms, one each for making arm and leg defenses, breastplates, and helmets (along with their crests and visors).

Once the suit had been forged, it was assembled; every joint was carefully checked to ensure a proper fit. The suit had to allow the knight to move his limbs with ease but also keep every part of him protected. The pieces were filed down until they fit perfectly. The armor was then passed to a millman, who polished the surface and smoothed any dents. Following this, the armorer reassembled the suit, adding straps, buckles, and padding.

How heavy was a suit of armor?

The average suit of armor weighed between 45 and 50 pounds, but was not as cumbersome as you might imagine. In fact, it weighed no more than the modern soldier's backpack, and, like today's soldier, the medieval knight had to be able to run, jump, and lie down in his armor. If necessary, a knight could dress himself in armor and vault onto his horse. Of course, he preferred to call upon his squire for help! A fully armored knight could even ford rivers if he were careful. The unfortunate Frederick Barbarossa, the Holy Roman Emperor, was not so careful: he drowned on his way to the Third Crusade in 1190.

How did a knight see with his helmet on?

Most helmets have long, narrow slits, or "sights," that one can see through. Just as you can see a room through a keyhole if you place your eye against the lock, so also the knight could gain a good view of the battlefield through these slits.

Think how hot it could get inside a helmet during a fierce battle! In an attempt to be as comfortable as possible, knights delayed putting on their helmets until they rode out onto the battlefield. Their helmets were fitted with visors, hinged metal guards, that were lowered to protect the face during the fight. When the knight was out of danger, the visor could be raised to admit cooling breezes.

How was armor decorated?

The most common form of decoration consisted of lines incised into the metal plate. To achieve this, one could *engrave*, or scratch, the design into the armor using a chisel-like implement called a burin. A second method was called *etching*, in which all the hard work is done by acid. The artist simply covered the piece in wax, or some other acid-resistant substance, and drew the design through it, revealing areas of the metal beneath as he went along. The design was eaten into the unprotected metal while it sat in an acid bath.

An *embossed* suit is one in which the decoration has been stamped into the metal from behind. This produces a wonderfully sculptural effect, allowing the decoration to stand out and catch the light. However, the stamping weakens the armor, so one usually only finds this method used on fancy parade armor.

In the 16th century, French noblemen wore suits of gold. Very chic! The gilder could either glue tissue-thin sheets of gold to the armor with a varnish, or apply a mixture of mercury and gold to the metal and heat it; the mercury evaporated, leaving the gold bonded to the armor.

By heating metal to about 622° F and then immediately immersing it in cold water, armor could be tinted blue. To cut a particularly dashing figure, the Emperor Maximilian had a "blued" suit decorated with gold.

How long did it take to make a suit of armor, and was it expensive?

It depended on how many people the armorer had working for him, and just how lavish the suit of armor was to be. Munitions armor was relatively quick to produce, since it was not made-to-measure and was seldom decorated. In the mid-16th century, Anton Peffenhauser of Augsburg, Germany, was commissioned to produce 600 suits in twelve weeks. He cheated by buying 300 from neighboring Nuremberg. Clearly, ready-made armor could be easily purchased in huge lots. In 1539, fearing a French invasion of England, Henry VIII bought 1200 suits from Cologne and 2700 from Antwerp.

It probably took about two months to forge a tailored suit of armor. If the armor was to be beautifully decorated with etched and gilded designs, the production time doubled. The fancier, more expensive armor was worn only at tournaments, where it was less likely to get damaged.

Hans Seusenhofer's accounts of 1527 provide us with a relative scale for the price of different types of armor. He charged 70 florins for etched tournament armor, 50 florins for battle armor, and 25 for a half-suit.

Armed

with Answers

How did one tell friend from foe on the battlefield?

In the days before armies wore uniforms, foot soldiers often added an identifying color to their clothes. The English royal house of Plantagenet, which reigned during the Middle Ages, got its name from the sprig of the broom, or *gênet*, plant that its supporters wore in their caps.

It was impossible to identify a knight in full armor with his helmet on. During the Battle of Hastings, in 1066, the Normans almost abandoned the field because a rumor spread that Duke William had been killed. He had to remove his helmet and show his face before he could rouse his troops on to victory and the conquest of England.

The armor-clad knight was identifiable by his coat of arms painted on his shield and sometimes emblazoned on his surcoat. Covered in mud, splattered with blood, and battered in the fray, however, the emblems would have been difficult to identify. Such designs were far more visible in the tournament parade. There, a knight's heraldic arms—comprising colored shapes, patterns, and animals—were easily admired. There too, one could enjoy the witty, “canting” arms, which played upon the knight's name. Thus, Sir Roger de Trumpington had trumpets on his coat of arms.



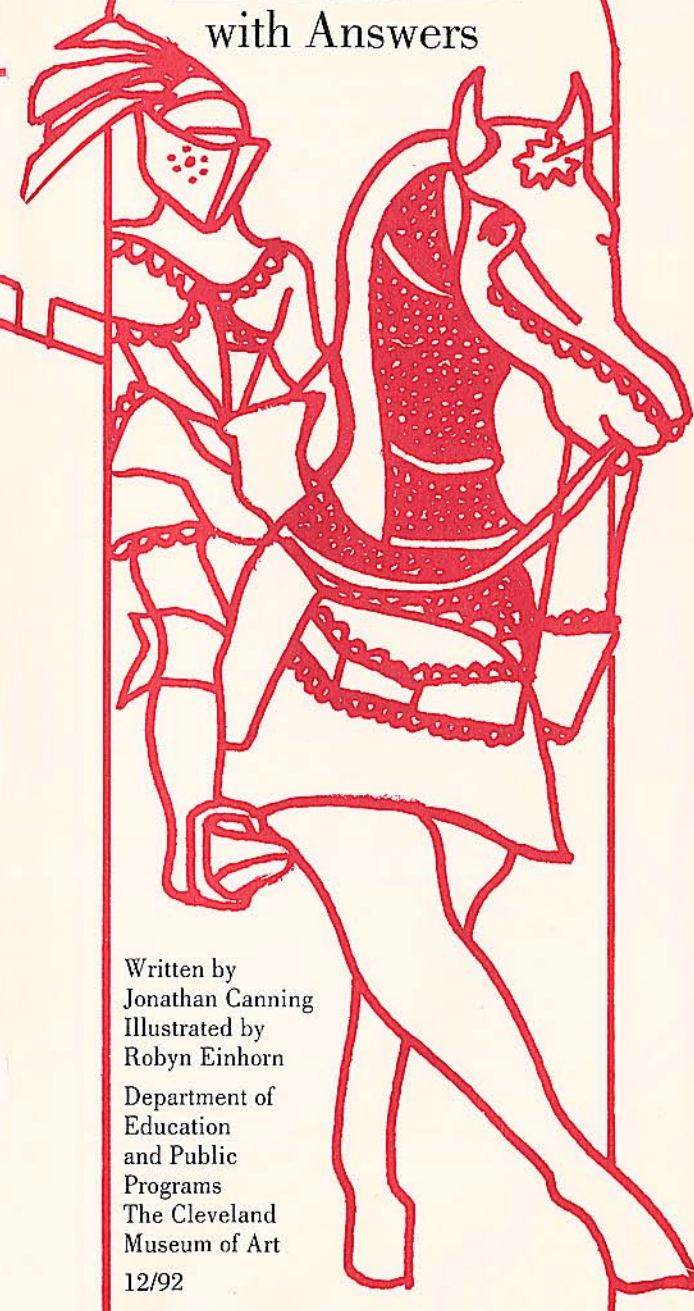
Could any weapon pierce armor?

The armorer and weapon-smith were always in competition with each other; the first strove to forge the impenetrable suit, while the second sought to pierce with new weapons.

Chain mail, with its tight, interlocking links, was invented to protect a knight against the broad blows of edge weapons, such as swords, pikes, and daggers. Weaponsmiths responded by developing the long bow and the crossbow, which could fire either finely tipped arrowheads, to go through the links, or broad-headed bolts, which could split the iron links apart. So effective was the crossbow that in 1139 the pope attempted to ban its use against fellow Christians. Armors met the challenge by adding metal plates to the hauberk, which led to the development of the full suit of plate armor.

A knight was almost invulnerable in his suit of armor. However, weapons such as maces and lances could unseat him or wear him down under their constant battering. The advent in the early 1500s of firearms that could project bullets with sufficient velocity to pierce steel brought about the end of “the knight in shining armor.”

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